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Removal of Western Dwarf Mistletoe Shoots on Jeffrey and Ponderosa Pine using Ethephon (Florel[R]) on Two California State Forests

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ABSTRACT

Ethephon (Florel[R]) was applied to female western dwarf mistletoe plants (Arceuthobium campylopodum) infecting Jeffrey pine (Pinus jeffreyi) and ponderosa pine (Pinus ponderosa) in September 1989. On Jeffrey pine, dwarf mistletoe branch infections were sprayed individually. On ponderosa pine, fifteen entire trees were sprayed. In Jeffrey pine, 82% of ethephon treated mistletoe branch infections were completely defoliated after five weeks, but new mistletoe shoots were sprouting on 92% of treated infections. In ponderosa pine, 65% of examined branch infections showed complete abscission and 59% of treated infections had resprouted in less than 5 weeks.

INTRODUCTION

Protection of ornamental trees against dwarf and leafy mistletoes has long been the goal of arborists and foresters. Direct treatment by removal of infected

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trees or pruning of branch infections seemed the only way to impede the parasite's long-term impact. Indirect treatments included favoring non-hosts. By 1972, over 335 chemical trials for control of dwarf mistletoe had been done in the United States, yet none had demonstrated the ability of a chemical to kill the parasite without killing the host (12). Recent use of a plant growth regulating chemical (ethephon) for removal of the epiphytic mistletoe system has renewed interest among researchers in chemical control of mistletoes.

The growth regulator Chipco® Florel® Pro (containing ethephon as the active ingredient) was registered in 1987 for use in the state of California for removal of dwarf mistletoe in ornamental conifers and elimination of undesirable fruits of several hardwoods. Ethephon releases ethylene during absorption by plant tissue which enhances abscission of older shoots of dwarf mistletoe plants (13).

Thorough application of ethephon to aerial stems of both leafy and dwarf mistletoe plants will cause shoot defoliation, but the endophytic system is not usually killed (6,9). The mistletoe plant will resprout, and over the next several years, will again produce fruits in abundance. Ethephon is not translocated, and success of ethephon application for control of dwarf mistletoe fruiting is dependent upon complete shoot coverage (13). A nonionic surfactant is recommended for use with Florel® (13).

Recommended label concentration of Chipco® Florel® Pro is 2700 ppm. Experimentally, ethephon has been used for reduction of fruit dissemination of dwarf mistletoe at rates ranging from 1200 ppm (2) to 5000 ppm (8,11). All rates of chemical gave abscission rates well above that of controls using only water or water plus surfactant. Defoliation rates ranged from 60 to 100 percent. The lower defoliation rates are attributed to incomplete plant coverage caused by problems related to using proper equipment and technique.

Ethephon has been tested on the following coniferous host-parasite combinations:

Arceuthobium	Host	Location	References
americanum	Pinus banksiana	Manitoba	1
americanum	Pinus contorta	Colorado, California	9,10
campylopodum	Pinus ponderosa	California, Idaho	3,11
campylopodum	Pinus jeffreyi	California	3
douglasii	Pseudotsuga menziesii	Oregon	11
laricis	Larix occidentalis	Oregon	11
pusillum	Picea mariana	Minnesota	7,8
vaginatum	Pinus ponderosa	Colorado, New Mexico	2,4,5,10

The objectives of this study are to continue our evaluation of ethephon's utility in California for dwarf mistletoe shoot removal by quantifying resprouting and comparing efficacy of direct plant and whole tree spraying.

METHODS

Tests with ethephon were conducted in 1988 and 1989 at two locations in northern California: Latour Demonstration State Forest (LDSF) and Boggs Mountain Demonstration State Forest (BMDSF). Latour DSF is located 40 miles northeast of Redding, and Boggs Mountain DSF is located near Middletown. Jeffrey pine on LDSF are at about 6500 feet, and the ponderosa pine at BMDSF are at 2000 feet.

At both locations, individual dwarf mistletoe plants treated in 1988 were re-evaluated for shoot resprouting and fruit production, and new tests were established.

1988 Trials - Regrowth and Fruiting Evaluation

In 1988, ethephon was applied to female dwarf mistletoe shoots on 3 California conifers: Arceuthobium campylopodum on Pinus ponderosa (BMDSF) and P. jeffreyi (LDSF) and Arceuthobium americanum on P. contorta (LDSF). Ethephon at a rate of 2500 ppm with a surfactant and water with surfactant as a control, was applied using a backpack sprayer to about 30 infections in each host-parasite combination. After 5 weeks abscission rates ranged from 96% to 100% in the chemical treatments compared to no shoot abscission in the controls (3). In 1989, these infections were reevaluated for shoot resprouting and fruit production.

1989 Trials - Individual Plant and Whole Tree Treatments

The new trials initiated in 1989 were: at LDSF previously untreated individual female dwarf mistletoe plants were treated and evaluated after five weeks; at BMDSF whole ponderosa pine trees were sprayed and effects on female dwarf mistletoe plants were evaluated five weeks later. Thirty trees with female dwarf mistletoe infections in the lower crown were tagged and numbered at each location. An infection equals one plant comprised of numerous shoots. Photographs were taken of representative infections.

At LDSF, infections were randomly selected in the lower crown of Jeffrey pines. Each infection was labelled with a numbered metal tag to indicate treatment. Shoots on each infection were counted and recorded.

At BMDSF, the number of dwarf mistletoe infections per ponderosa pine were counted and the sex of each noted. Three female infections in the lower crown of each tree were flagged, tagged to indicate treatment, and shoot numbers recorded. Average dbh of treated trees was 8 inches (range: 4.2"-12.5"); average height was 39 feet (range: 18'-60'). Average dbh of control trees was 10 inches (range: 5.8"-13.0"); average height was 48 feet (range: 22'-67').

Ethephon at 2500 ppm was applied directly to the dwarf mistletoe branch infections on Jeffrey pine (LDSF) using a backpack sprayer. The ponderosa pine dwarf mistletoe plants on BMDSF received whole tree spraying at a 2700 ppm ethephon rate. A surfactant, Ortho x-77, was mixed with the ethephon and with the water controls at a 0.1% rate. All treatments were sprayed to runoff of material. Ethephon application occurred in the first week of September 1989, and was timed to occur approximately 3 to 4 weeks prior to the onset of seed

discharge estimated to be late September to early October. Ethephon and surfactant were measured and mixed just prior to use to prevent pH change and conversion of the material to ethylene.

Effect of ethephon treatment on abscission of dwarf mistletoe plants was assessed 5 weeks after treatment. Numbers of shoots present in ethephon treated infections were determined by count. The number of shoots remaining on untreated infections was estimated. Trees will be examined yearly each fall for several years to follow mistletoe resprouting and fruit production.

RESULTS

The results of the 1988 trials in Jeffrey and ponderosa pines reevaluated in 1989 are shown in Table 1. One year after application of 2500 ppm ethephon, a high percentage of western dwarf mistletoe branch infections were reprouting on both Jeffrey and ponderosa pine.

Table 1. Western dwarf mistletoe shoot resprouting and fruit production one year after individual branch infection treatment with 2500 ppm ethephon. Results are percent of 30 branch infections per treatment.

Treatment	Shoot Resprouting	Fruit Production
	%	%
Jeffrey pine (LDSF)		
Ethephon	83	23
Control	94	39
Ponderosa pine (BMDSF)		
Ethephon	48	4
Control	95	88

1989 Trials

Results of 1989 ethephon treatment applied with a backpack sprayer onto individual western dwarf mistletoe branch infections on Jeffrey pine are shown in Table 2. Five weeks after spraying with 2500 ppm ethephon, 82% of western dwarf mistletoe branch infections were completely defoliated.

Table 2. Western dwarf mistletoe shoot abscission 5 weeks after application of 2500 ppm ethephon sprayed directly onto female dwarf mistletoe branch infections on Jeffrey pine at Latour Demonstration State Forest. Values are percent of 30 branch infections per treatment.

Abscission Type	Shoot Abscission
	%
Treated	
complete[1]	82
shoots only[2]	18
shoots and fruits[3]	0
Control[4]	0

[1] All external shoots defoliated.
[2] Shoot abscission incomplete, one or more immature shoots remained on plant.
[3] Shoot abscission incomplete, one or more shoots with fruits remained on plant.
[4] Control was treated with water and surfactant only.

Results of 1989 whole tree application of ethephon to control western dwarf mistletoe on ponderosa pine are shown in Table 3. Five weeks after spraying with 2700 ppm ethephon, 65% of western dwarf mistletoe infections were completed defoliated.

Table 3. Western dwarf mistletoe female shoot abscission rates 5 weeks after whole tree, ground-based application of 2700 ppm ethephon on ponderosa pine at Boggs Mountain Demonstration State Forest. Values are percent of 30 branch infections per treatment.

Abscission Type	Shoot Abscission
	%
Treated	
complete[1]	65
shoots only[2]	28
shoots & Fruits[3]	7
Control[4]	0

[1] All external shoots defoliated.
[2] Shoot abscission incomplete, one or more immature shoots remained on plant.
[3] Shoot abscission incomplete, one or more shoots with fruits remained on plant.
[4] Control was treated with water and surfactant only.

DISCUSSION

In 1988, ethephon was applied with a backpack sprayer to western dwarf mistletoe on Jeffrey pine at LDSF, in an area adjacent to this year's trial. 96% of western dwarf mistletoe shoots were eliminated five weeks after application (3). After one year, a large number of mistletoe shoots were resprouting on the treated branches; 83% of shoots had regrown versus 94% for untreated controls (See Table 1). This year's trial produced similar results, with a high level of resprouting (92%) detected a few weeks after treatment. These new shoots appeared to be healthy. However they will be followed for observation of any latent effect of the spraying, such as early abscission.

In 1988, ethephon was also applied on western dwarf mistletoe on ponderosa pine and lodgepole pine dwarf mistletoe on lodgepole pine (3). A backpack sprayer was used in all tests and identical techniques were executed. After one year, 48% of the treated shoots resprouted on the ponderosa pine (Table 1), while less than 10% of the shoots on lodgepole pine resprouted. Western dwarf mistletoe on Jeffrey and ponderosa pine resprouted rapidly after treatment with 2500-2700 ppm ethephon. This agrees with other trials on these species that indicate that shoot regrowth following ethephon application is rapid for western dwarf mistletoe on ponderosa pine and slower for lodgepole pine dwarf mistletoe shoots on lodgepole pine (9,11). Parks and Hoffman (11) noted resprouting of dwarf mistletoe one year after treatment of Douglas-fir dwarf mistletoe on Douglas-fir and of western dwarf mistletoe on ponderosa pine, but only 2% resprouting of larch dwarf mistletoe on western larch. Resprouting on Douglas-fir appeared to be dependent upon ethephon application rate; 37% of the 1250 ppm treatment infections resprouted, while no resprouting occurred in the 5000 ppm treatment. Effect of application rate on resprouting has not been tested in California.

Researchers have applied ethephon with several types of spray devices. Hand, backpack, gravity-fed, and hydraulic sprayers, and aerial applications have been made (9). Aerial application was not effective and ground spray application became less effective as plant coverage was required higher in the tree. Higher targets are difficult to fully cover with the chemical, while lower targets are easier to spray and may also receive coverage through incidental application when targets above are sprayed. In our whole tree spray trial at BMDF, branch infections in the lower crown were defoliated more completely than infections above 20 feet.

Complete coverage of aerial shoots is necessary to achieve desired results. Ethephon is not translocated and therefore must reach the plant surface to be effective. In our trials one cause of incomplete abscission was needle clusters blocking the chemical from reaching the target. Systemic infections will need careful application to treat all seed-bearing shoots.

What is a practical time between treatments? Intervals between treatments of three to four years, or longer, have been suggested (4,10). However, in order to properly assess the timing between treatments, particular host and pathogen and differences in application technique and equipment must be considered. General guidelines for frequency of use need to be developed.

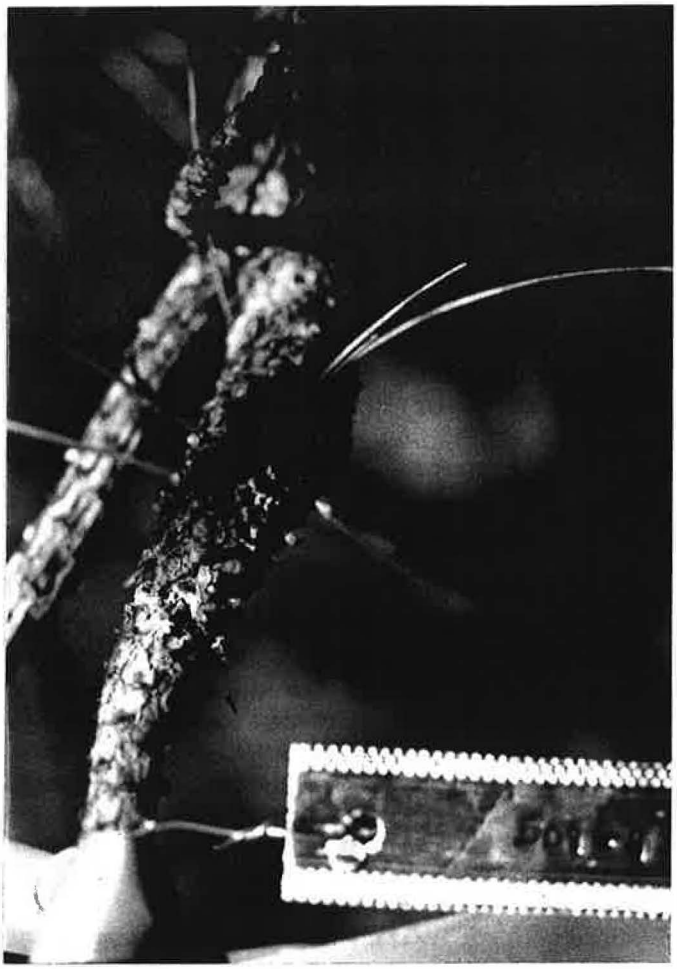

FIG. 1. Mistletoe shoots emerging from ethephon treated western dwarf mistletoe branch infection on ponderosa pine, 5 weeks after treatment (BMDSF, 509-9).

FIG. 2. Whole tree spraying with 2700 ppm ethephon. Trees were sprayed to run-off.

CONCLUSIONS

Ethephon appears to be a useful chemical if expectations are tempered by knowledgeable use of the material. Practical use of ethephon is limited to reducing disease spread among high value hosts. Ethephon is not useful in forest-wide applications against dwarf mistletoe because it usually does not kill the parasite and, therefore, large area applications must be repeated at continued expense. Trees considered for treatment should be in good health (despite mistletoe presence). As ethephon does not kill the treated plants, those dwarf mistletoe plants surviving will adversely affect host vigor.

Timing of treatment (time of year), optimal weather conditions (no rain or wind), and complete plant coverage is important for best results. Frequency of application criteria need to be developed for the species and site.

Chemical application should be made by a licensed applicator. Ethephon should be used in accordance with the label, and especially with regard to usage only on "ornamental conifers".

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